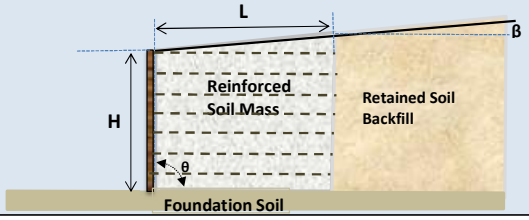
EXTERNAL STABILITY ANALYSIS OF MSE WALL AND EMBANKMENT

PROJECT INFORMATION	
Project Name	
Project No.	
Project Location	
Analyzed By	
Reviewed By	

INPUT PARAMETERS		
WALL DATA:		
Design Height, H	20.00 feet	
Wall Face Slope Angle, θ	90.00 degrees	
Backfill Slope Angle, β	0.00 degrees	
Trial Reinforcement Length, L	20.00 feet	*(OK)*
REINFORCED SOIL MASS:		
Effective Friction Angle, ϕ_r'	34.00 degrees	
Effective Unit Weight, γ_r'	120.00 pcf	
RETAINED SOIL BACKFILL:		
Effective Friction Angle, ϕ_f'	32.00 degrees	
Effective Unit Weight, γ_f'	120.00 pcf	
FOUNDATION SOIL:		
Effective Friction Angle, ϕ_b'	32.00 degrees	
Effective Cohesion, c_b'	0.00 psf	
Effective Unit Weight, γ_b'	120.00 pcf	
LOADING:		
Traffic Surcharge Load, q	240.00 psf	
Horizontal Seismic Acceleration Coefficient, k_h	0.400 g	



REFERENCES:

1. Caltrans Memo to Designers 5-8, 1991, "Mechanically Stabilized Embankment," January 1991.
2. Caltrans Bridge Design Aids, 2002,"Mechanically Stabilized Embankment," pp. 3-8.1 - 3-8.10, April 2002.
3. Caltrans Bridge Design Specifications, 2004, Section 5 - Retaining Walls, pp. 5-36 to 5-38.
3. Federal Highway Administration (FHWA), 2001,"Mechanically Stabilized Earth Walls and Reinforced Soil Slopes and Construction Guidelines," Publication No. FHWA-NHI-00-043, March 2001.
4. Vesic, A.S. , 1973, "Analysis of Ultimate Loads of Shallow Foundations," JSMFD, ASCE, Vol. 99, SM 1, pp.45-73, Jan 1973.

CALCULATED FORCES AND MOMENTS		
Static Active Earth Pressure Coefficient, K_a	0.307	Based on Coulomb Earth Pressure Theory
Seismic Active Earth Pressure Coeff., K_{ae}	0.607	Based on Simplified Mononobe-Okabe Theory by Seed and Whitman (1970)
Effective Wall Height for Static Active Thrust Force, H_1	20.00 feet	$H_1 = H + L \tan \beta$
Effective Wall Height for Seismic Active Thrust Force, H_2	20.00 feet	$H_2 = H + (0.5\ H \tan \beta)/(1 - 0.5 \tan \beta)$
Static Active Thrust Force From Retained Fill, F_T	7.37 kips/ft of wall	$F_T = 1/2\ \gamma_f K_a\ (H_1)^2$
SeismicActive Thrust Force From Retained Fill, P_{ae}	7.20 kips/ft of wall	$P_{ae} = 1/2\ \gamma_f\ (K_{ae} - K_a)\ (H_2)^2$
Horizontal Component of Static Active Thrust Force, F_1	7.37 kips/ft of wall	$F_1 = F_T \cos \beta$
Horizontal Force From Surcharge Load, F_2	1.47 kips/ft of wall	$F_2 = q\ H\ K_a$
Horizontal Inertial Force From Reinforced Soil Mass, P_{ir}	9.60 kips/ft of wall	$P_{ir} = 0.5\ k_h\ \gamma_f\ H_2\ H$
Horizontal Inertial Force From Sloping Soil Surcharge, P_{is}	0.00 kips/ft of wall	$P_{is} = 0.125\ k_h\ \gamma_f\ (H_2)^2 \tan \beta$
Weight of Reinforced Soil Mass, V_1	48.00 kips/ft of wall	$V_1 = \gamma_r\ H\ L$
Weight of Sloping Backfill, V_2	0.00 kips/ft of wall	$V_2 = 1/2\ \gamma_f\ L\ (L \tan \beta)$
Sum of Resisting Moments, M_R	480.00 kip-ft/ft of wall	$M_R = V_1\ (L/2) + V_2\ (2/3\ L)$
Sum of Overturning Moments (Static), M_{OS}	63.91 kip-ft/ft of wall	$M_{OS} = F_1\ (H/3) + F_2\ (H/2)$
Sum of Overturning Moments (Static + Seismic), M_{OD}	203.11 kip-ft/ft of wall	$M_{OD} = M_{OS} + P_{ir}\ (H/2) + P_{is}\ [H + 1/3\ (H_2 - H)] + 0.5\ P_{ae} \cos \beta\ (0.6\ H_2)$
Sum of Vertical Forces, V_T	48.00 kips/ft of wall	$V_T = V_1 + V_2 + F_T \sin \beta$
Sum of Horizontal Resisting Forces, P_R	29.99 kips/ft of wall	$P_R = V_T\ \tan [\min\ (\phi_r, \phi_f)]$
Sum of Horizontal Driving Forces (Static), P_{DS}	8.85 kips/ft of wall	$P_{DS} = F_1 + F_2$
Sum of Horizontal Driving Forces (Static + Seismic), P_{DD}	22.05 kips/ft of wall	$P_{DD} = P_{DS} + P_{ir} + P_{is} + 0.5\ P_{ae} \cos \beta$

CHECK SLIDING FAILURE		
Static Factor of Safety = P_R / P_{DS}	3.39 ≥ 1.5 ?	*(OK)*
Seismic Factor of Safety = P_R / P_{DD}	1.36 ≥ 1.2 ?	*(OK)*

CHECK OVERTURNING FAILURE		
Static Factor of Safety = M_R / M_{OS}	7.51 ≥ 2.0 ?	*(OK)*
Eccentricity, $e_s = [L/2 - (M_R - M_{OS}) / V_T]$	1.33 ft < (L/6) ?	*(OK)*
Seismic Factor of Safety = M_R / M_{OD}	2.36 ≥ 1.5 ?	*(OK)*

CHECK FOUNDATION BEARING FAILURE		
Bearing Capacity Factors: N_c, N_q, and N_γ	Nc = 35.5, Nq = 23.18, Ng = 30.22	Based on Vesic (1973)
Maximum Bearing Pressure at the Wall Base, σ_v	2.77 ksf	$\sigma_v = V_T / (L - 2\ e_s)$
Ultimate Bearing Capacity, q_{ult}	31.44 ksf	$q_{ult} = c_b\ N_c + 0.5\ \gamma_b\ N_\gamma\ (L - 2\ e_s)$
Static Factor of Safety = q_{ult} / σ_v	11.35 ≥ 2.5 ?	*(OK)*